

Application No. 10/076,458
Amendment under 37 CFR 1.111
Reply to Office Action dated August 22, 2003
December 22, 2003

IN THE CLAIMS

Please substitute the following claims for the pending claims with the same numbers, respectively:

Claim 1 (Currently amended): A circuit board testing apparatus for testing a plurality of wirings formed on a circuit board, each wiring having a first terminal and second terminal at opposite ends of each of the wirings, the apparatus comprising:

an electromagnetic wave irradiator which irradiates an electromagnetic wave onto a first terminal of a selected one of the wirings to discharge electrons from the irradiated terminal by photoelectric effect;

an electrode disposed at such a position as to trap the discharged electrons;

~~a voltage supplier which produces a difference of electric potential between the electrode portion and the other terminal of the selected wiring so that the electrode portion has an electrical potential higher than the other terminal of the selected wiring~~ operatively connected between the electrode and the second terminal of the selected wiring to apply voltage

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therebetween so that the electrode has a higher potential than
the second terminal of the selected wiring, the voltage supplier
including a probe operatively connected to the voltage supplier
and connectable to the second terminal of the selected wiring;

a current detector which detects a an electric current
~~caused by electrons trapped by the electrode and flows through
the selected wiring via the electrode~~ that passes through the
electrode, the probe and the second terminal of the selected
wiring; and

a judger which determines existence of an open-circuit
~~and/or short circuit~~ in the selected wiring based on the current
detected by the current detector.

Claim 2 (Original): The circuit board testing apparatus
according to claim 1, wherein the electromagnetic wave irradiator
includes a deflector which changes the direction of the
electromagnetic wave in such a manner as to selectively and
successively irradiate the first terminals of the plurality of
wirings with the electromagnetic wave.

Claim 3 (Currently amended): The circuit board testing

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apparatus according to claim 1, wherein the voltage supplier includes a power source, and wherein the probe is a connector which electrically connects the power source, the electrode, the second terminal of the selected wiring, and the current detector with one another to thereby constitute a closed circuit thereby including the a space between the electrode and the first terminal of the selected wiring through which the discharged electrons flow.

Claim 4 (Original): The circuit board testing apparatus according to claim 3, wherein the connector includes a plurality of probes which are to be brought into contact with the respective second terminals of the plurality of wirings to establish electrical connections therewith, and a switch which selectively connects one of the plurality of probes to the power source.

Claim 5 (Currently amended): The circuit board testing apparatus according to claim 1, further comprising a housing which encloses the first terminals of the plurality of wirings to constitute an airtight closed space, and a depressurizer which

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depressurizes the airtight closed space.

Claim 6 (Original): The circuit board testing apparatus according to claim 5, wherein the upper portion of the housing is transparent, the electric magnetic wave irradiator is located above the housing to irradiate the first terminals through the upper portion of the housing, and the electrode is formed on the housing.

Claim 7 (Original): The circuit board testing apparatus according to claim 6, wherein the electrode includes a transparent electrode formed on an upper portion of the housing.

Claim 8 (Original): The circuit board testing apparatus according to claim 6, wherein the electrode portion includes a meshed electrode formed on the upper portion of the housing, and the electromagnetic wave irradiator irradiates the first terminal through the upper portion of the housing not covered by the meshed electrode.

Claim 9 (Currently amended): The circuit board testing

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apparatus according to claim 6, wherein the side wall of the housing is made of electrically conductive material and is electrically connected to the voltage supplier so as to be applied with the higher potential and to function as the electrode to trap the discharged electrons.

Claim 10 (Currently amended): The circuit board testing apparatus according to claim 1, wherein the voltage supplier includes a power source having ~~two poles~~ a plus terminal and a minus terminal, and a connector which connects the selected wiring to ~~one pole~~ the minus terminal of the power source, and at least a part of the unselected wirings to the ~~other pole~~ the plus terminal of the power source so that the wirings connected with the ~~other pole~~ plus terminal of the power source ~~serves~~ serve as the electrode to trap the discharged electrons.

Claim 11 (Currently amended): The circuit board testing apparatus according to claim 1, wherein the voltage supplier includes a power source having ~~at least two poles~~ a plus terminal and a minus terminal, and a switch arrangement which connects the selected wiring to ~~one pole~~ the minus terminal of the power

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source, and all unselected wirings to the ~~other pole~~ plus terminal of the power source so that the wirings connected with the ~~other pole~~ plus terminal of the power source ~~serves~~ serve as the electrode to trap the discharged electrons.

Claim 12 (Original): The circuit board testing apparatus according to claim 1, wherein the voltage supplier includes a power source, and a switch which connects the second terminal of the selected wiring to the power source.

Claim 13 (Canceled):

Claim 14 (Currently amended): A circuit board testing apparatus for testing continuity and/or a short-circuit of in wirings formed on a circuit board, each wiring having first and second terminals at opposite ends of the wiring, the apparatus comprising:

an electromagnetic wave irradiator which irradiates the first terminals of the wirings with an electromagnetic wave to allow electrons to be discharged from the first terminals by photoelectric effect;

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an electrode arranged to trap discharged electrons;

~~a voltage supplier for applying a voltage between the electrode and the second terminals of the wiring in a manner that voltage at the electrode becomes higher than voltage at the second terminals of the wirings~~ including a probe operatively connected to the voltage supplier and connectable to at least one of the second terminals of the wirings, the voltage supplier being operatively connected between the electrode and the at least one of the second terminals to apply voltage therebetween so that the electrode has a higher potential than the at least one of the second terminals;

~~a current detector which detects an electric current which is caused by electrons trapped by the electrode and flows through the wirings via the electrode~~ that passes through the electrode, the probe and the at least one of the second terminals; and

a judger which determines existence of an open-circuit and/or a short-circuit of the wirings in at least one of the wirings based on the current detected by the current detector.

Claim 15 (Original): The circuit board testing apparatus according to claim 14, wherein the electromagnetic wave

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irradiator is arranged to alternatively irradiate the terminals one at a time, and the voltage supplier is to be alternatively connected with the second terminals of the wirings one at a time.

Claim 16 (canceled):

Claim 17 (canceled):

Claim 18 (canceled):

Claim 19 (canceled):

Claim 20 (canceled):

Claim 21 (canceled):

Claim 22 (canceled):

Claim 23 (Currently amended): A circuit board testing apparatus for testing a plurality of wirings formed on a circuit board, each wiring having a first and second terminals at

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opposite ends of the wiring and the first terminals of the wirings being exposed on one surface of the circuit board, comprising:

an electromagnetic wave irradiator which collectively irradiates the first terminals of the wirings with electromagnetic wave to discharge electrons from the first terminals by photoelectric effect;

an electrode arranged to trap the discharged electrons;

a selector for selecting one of the wirings;

~~a voltage supplier which produces a difference of electric potential between the electrode and the second terminal of a selected wiring so that the electrode has an electrical potential higher than that of the second terminal of the selected wiring~~
including a probe operatively connected to the voltage supplier and connectable to at least one of the second terminals of the wirings, the voltage supplier operatively connected between the electrode and the at least one of the second terminals to apply voltage therebetween so that the electrode has a higher potential than the at least one of the second terminals;

a current detector which detects a an electric current ~~caused by electrons trapped by the electrode portion to flow~~

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~~through the selected wiring via the electrode~~ that passes through the electrode, the probe, and the at least one of the second terminals; and

a judger which judges continuity and/or a short-circuit of the selected wiring in at least one of the wirings based on the detected electric current detected by the current detector.

Claim 24 (Currently amended): The circuit board testing apparatus according to claim 23, wherein the voltage supplier includes a power source having a ~~first~~ plus pole connected to the electrode and ~~the second~~ a minus pole connected to the second terminal of the ~~target~~ selected wiring, and the selector includes a switch arrangement for electrically connects the second terminals of the wirings other than the selected wiring, to the ~~first~~ plus pole of the power source.

Claim 25 (Currently amended): The circuit board testing apparatus according to claim 23, wherein the voltage supplier includes a power source having a ~~first~~ plus pole connected to the electrode and a ~~second~~ minus pole connected to the second terminal of the ~~target~~ selected wiring, and the selector has a

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switch arrangement for electrically connecting the second terminal of the selected wiring to the ~~second~~ minus pole of the power source by way of the current detector, and the respective second terminals of the wirings other than the selected wiring to the ~~second~~ minus pole of the power source bypassing the current detector.

Claim 26 (Currently amended): The circuit board testing apparatus according to claim 25, wherein the selector includes a switch to select one state where the second terminal of the selected wiring is electrically connected to the ~~second~~ minus pole of the power source by way of the current detector and the second terminals of the wirings other than the selected wiring are electrically connected to the ~~second~~ minus pole of the power source bypassing the current detector, and another state where the second terminal of the selected wiring is electrically connected to the ~~second~~ minus pole of the power source by way of the current detector and the second terminals of the wiring other than the selected wiring are electrically connected to the ~~first~~ plus pole of the power source.

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Claim 27 (Currently amended): The circuit board testing apparatus according to claim 23, further comprising a housing which encloses the second terminals of the plurality of wirings to form an airtight closed space, and a depressurizer which depressurizes the airtight closed space.

Claim 28 (Original): The circuit board testing apparatus according to claim 27, wherein the upper wall of the housing is transparent, the electromagnetic wave irradiator is located above the housing to irradiate the first terminals through the transparent wall, and the electrode is formed on the housing in the manner allowing the passage of the electromagnetic wave through the transparent wall.

Claim 29 (canceled):

Claim 30 (Currently amended): A method for testing continuity and/or a short-circuit of wirings in at least one wiring formed on a circuit board, each wiring having a first and second terminals, the method comprising the steps of:

providing an electrode operatively connected to a probe

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which is selectively connectable to at least one of the second terminals;

irradiating at least one of the ~~first terminal~~ first terminals of ~~a wiring~~ the wirings with an electromagnetic wave to discharge electrons from the ~~terminal~~ at least one of the first terminals into a space by photoelectric effect;

trapping ~~the~~ discharged electrons by ~~an~~ the electrode having a potential higher than ~~that~~ at least one of the second ~~terminal terminals~~ of the ~~wiring~~ wirings ~~to allow and allowing~~ a current caused by ~~the~~ trapped electrons to flow ~~from~~ through the electrode, the probe and the at least one of the second ~~terminal~~ terminals ~~through the wiring~~; and

detecting the current that flows through the electrode, the probe and the at least one of the second terminals; and

judging continuity and/or a short-circuit of in at least one of the ~~wiring~~ wirings based on the current flowing through the wiring.

Claim 31 (Currently amended): The method according to claim 30, further comprising the following steps of which are carried out prior to said step of irradiating:

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enclosing the space into which electrons are discharged; and
depressurizing the closed space, ~~those steps being carried~~
~~out before the irradiation step.~~

Claim 32 (Currently amended): The method according to claim
30, wherein said step of irradiating includes the electromagnetic
~~wave is~~ selectively and successively ~~irradiated onto~~ irradiating
the first terminals of the wirings one by one, and an electrical
potential difference is produced between the electrode and the
respective second terminal of the selected wiring of the wiring
being irradiated in such a manner that the electrode has a
potential higher than that of the ~~selected wiring~~ respective
second terminal.

Claim 33 (Currently amended): The method according to claim
30, wherein said step of irradiating includes the electromagnetic
~~wave is~~ selectively and successively ~~irradiated onto~~ irradiating
the ~~one~~ first terminals of the wirings one by one, and a
difference of electric potential is produced between the
electrode and a second terminal of ~~the~~ a wiring adjacent to the
~~selected wiring~~ being irradiated in such a manner that the

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electrode has a potential higher than that of the second terminal of the wiring adjacent to the ~~selected wiring~~ being irradiated.

Claim 34 (Currently amended): The method according to claim 30, wherein said step of irradiating includes ~~the electromagnetic wave is~~ selectively and successively ~~irradiated onto~~ irradiating the first terminals of the wirings, and a difference of electric potential is produced between the electrode and the at least one of the second terminal terminals of the selected wiring or between the electrode and at least one of the second terminal terminals of the wiring wirings adjacent to the ~~selected wiring~~ being irradiated in such a manner that the electrode has a potential higher than that of the at least one of the second terminal terminals of the selected wiring or the wiring t- adjacent to the ~~selected wiring~~.

Claim 35 (canceled):

Claim 36 (canceled):

Claim 37 (canceled):

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Claim 38 (canceled):

Claim 39 (canceled):

Claim 40 (canceled):

Claim 41 (canceled):

Claim 42 (canceled):

Claim 43 (canceled):

Claim 44 (canceled):

Please add new claims 45-56 as follows:

Claim 45 (New): A circuit board testing apparatus for testing a plurality of wirings formed on a circuit board, each wiring having a first terminal and second terminal at opposite ends of each of the wirings, the apparatus comprising:

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an electromagnetic wave irradiator which irradiates an electromagnetic wave onto a first terminal of a first selected wiring to discharge electrons from the irradiated terminal by photoelectric effect;

an electrode disposed at such a position as to trap discharged electrons;

a voltage supplier operatively connected between the electrode and a second terminal of a second selected wiring to apply voltage therebetween so that the electrode has a higher potential than the second terminal of the second selected wiring, the voltage supplier including a probe operatively connected to the voltage supplier and connectable to the second terminal of the second selected wiring;

a current detector which detects an electric current that passes through the electrode, the probe and the second terminal of the second selected wiring; and

a judger which determines existence of a short-circuit in the first selected wiring based on the current detected by the current detector.

Claim 46 (New): The circuit board testing apparatus

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according to claim 45, wherein the electromagnetic wave irradiator includes a deflector which changes the direction of the electromagnetic wave in such a manner as to selectively and successively irradiate the first terminals of the plurality of wirings with the electromagnetic wave.

Claim 47 (New): The circuit board testing apparatus according to claim 45, wherein the voltage supplier includes a power source, and wherein the probe is a connector which electrically connects the power source, the electrode, the second terminal of the second selected wiring, and the current detector with one another to thereby constitute a closed circuit including a space between the electrode and the first terminal of the selected wiring through which the discharged electrons flow.

Claim 48 (New): The circuit board testing apparatus according to claim 47, wherein the connector includes a plurality of probes which are to be brought into contact with the respective second terminals of the plurality of wirings to establish electrical connections therewith, and a switch which selectively connects one of the plurality of probes to the power

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source.

Claim 49 (Currently amended): The circuit board testing apparatus according to claim 45, further comprising a housing which encloses the first terminals of the plurality of wirings to constitute an airtight closed space, and a depressurizer which depressurizes the airtight closed space.

Claim 50 (Original): The circuit board testing apparatus according to claim 49, wherein the upper portion of the housing is transparent, the electric magnetic wave irradiator is located above the housing to irradiate the first terminals through the upper portion of the housing, and the electrode is formed on the housing.

Claim 51 (Original): The circuit board testing apparatus according to claim 50, wherein the electrode includes a transparent electrode formed on an upper portion of the housing.

Claim 52 (Original): The circuit board testing apparatus according to claim 50, wherein the electrode portion includes a

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meshed electrode formed on the upper portion of the housing, and the electromagnetic wave irradiator irradiates the first terminal through the upper portion of the housing not covered by the meshed electrode.

Claim 53 (Currently amended): The circuit board testing apparatus according to claim 50, wherein the side wall of the housing is made of electrically conductive material and is electrically connected to the voltage supplier so as to be applied with the higher potential and function as the electrode to trap the discharged electrons.

Claim 54 (Currently amended): The circuit board testing apparatus according to claim 45, wherein the voltage supplier includes a power source having a plus terminal and a minus terminal, and a connector which connects the first selected wiring to the minus terminal of the power source, and at least a part of the unselected wirings to the plus terminal of the power source so that the wirings connected with the plus terminal of the power source serve as the electrode to trap the discharged electrons.

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Claim 55 (Currently amended): The circuit board testing apparatus according to claim 45, wherein the voltage supplier includes a power source having a plus terminal and a minus terminal, and a switch arrangement which connects the first selected wiring to the minus terminal of the power source, and all unselected wirings to the plus terminal of the power source so that the wirings connected with the plus terminal of the power source serve as the electrode to trap the discharged electrons.

Claim 56 (Currently amended): The circuit board testing apparatus according to claim 45, wherein the voltage supplier includes a power source, and a switch which connects the power source to the second terminal of the second selected wiring, and wherein the second selected wiring is adjacent to the first selected wiring.